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PROGRAM AND KNOWLEDGE TRANSFER IN TEACHING IN INDOOR AIR SCIENCES

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Abstract

The focus of this paper is the universality of teaching and training in the area of science of indoor air quality and the practice of indoor air quality management. The key questions, which the paper addresses, are: (i) how universal are approaches to teaching and training in the area of science and practice of indoor air quality, and (ii) is it possible, practical or desirable to transfer training or university degree programs from one geographical, cultural or economical reality to another? The paper is an attempt to answer the two questions from the broad perspective of linking parallels between teaching in indoor air sciences and teaching in an interdisciplinary area in general, and also from the perspective of personal experience from university and training course teaching in various places in the world. The conclusion drawn is that transfer of knowledge and technology in teaching in the area of indoor air sciences is possible and desirable. The success of program transfer depends on the understanding of the philosophy of teaching in this area as well as on understanding local needs requirements and limitations.

Introduction

The focus of this paper addresses the universality of teaching and training in the area of science of indoor air quality and the practice of indoor air quality management. More specifically, two questions will be addressed:

- How universal are approaches to teaching and training in the area of science and practice of indoor air quality?
- Is it possible, practical, or desirable to transfer training courses or university degree programs from one geographical, cultural, social or economic reality to another?

The paper is an attempt to answer the two questions from the broad perspective of linking parallels between teaching in indoor air sciences and teaching in an interdisciplinary area in general, and also from the perspective of personal experience from university and training course teaching in various places in the world. As presented here, the paper explores further and extends these concepts, which were first developed and presented earlier (Morawska 1999).

As a starting point for this discussion the question of how universal teaching programs are in general, could be investigated. For this purpose a brief analysis of a few different areas of university teaching will be discussed first. As a start let us consider, for example a university degree in mathematical or physical sciences. Would there be any difference in the program if it was taught in New York, Budapest or Kuala Lumpur? There does not appear to be any reasons for differences in the core units of the program. The only difference could relate to some elective subjects, which are often outside the discipline of study. The same would apply for example to chemistry or any other natural science, even an interdisciplinary such as bio-geo-chemistry. Ecology? This science is a multidisciplinary approach involving biology, chemistry and physics in the first instance. The basic principles would be the same although it would not make too much sense to teach the details of, for example, ecological system of boreal and temperate climate forests in a tropical country. What about engineering? The vast majority of the program would be the same, however there would be differences relating to different standards and norms used in different countries, or materials applied in different climatic zones. Law programs? In most cases the fraction of units that are locally specific would be much higher than in engineering. So in summary, while certain discipline university teaching programs are universal, some would differ too significantly to be considered transferable.

Let us consider now a more complicated teaching area: ambient air quality. This is an interdisciplinary and very applied area, which involves the consideration of emissions of chemical substances from anthropogenic and natural sources, dispersion of pollutants, interaction of pollutants with receptors including humans, the exposure of humans, the effects of air pollutants on man and environment, risk perception and public awareness, control action on sources, emission and air quality standards, technological capabilities, technology transfer, and economic estimates in the sense of comparing control costs with benefits. Again, some basic principles (such as emissions, meteorology of dispersion, effects on man and environment) would be independent on the geographical area considered. However, control action on sources and technological solutions while transferable in principle, would depend on the economic capabilities and technological feasibility including human resources. Air quality standards vary widely between countries and the application of economic estimates of costs and benefits requires the valuing of human life and well-being of ecosystems which will be considered differently in different economic, cultural and social regions. Nevertheless, the basics of compliance testing with given air quality standards and the basics of a cost benefit comparison remain the same.

Teaching and training in science and the practice of indoor air presents an even more complicated case. While being a very interdisciplinary and very applied area as is the case of ambient air, indoor air quality also depends on the widely varying range of buildings in different geographical regions, on the traditional and social behaviour of the building inhabitants, their awareness of indoor air problems, and is much less apt to governmental regulations. It is thus unavoidable that while certain aspects of the teaching and training programs are universal, other aspects are country or area specific. How large a problem does it present, and what are the solutions for the exchange of programs?

Universal versus local approaches to education and training in IAQ

Similarities and differences between different levels of education and training in IAQ can be considered in three key areas:

- Content of the material
- Organisation of teaching and training
- Economical aspects: possibilities and priorities

Content of the material

In considering teaching and training programs in indoor air science and practice a key point is that the area of study is interdisciplinary. Indoor air science includes the disciplines of construction physics, building material chemistry, contaminants of indoor sources, indoor/outdoor relationships, air conditioning and ventilation techniques, use and efficiency of burning materials, chimney construction techniques and use of open stoves, health effects such as sick building syndrome (SBS), building-related illnesses (BRI) and multi-chemical sensitivity (MCS) but also respiratory and cardiovascular diseases, risk assessment and risk management techniques. While there is an ongoing discussion on defining whether indoor air science is an independent discipline (Morawska 1998), for the purpose of this paper indoor air science is not considered itself a discipline, but as an *application of knowledge from many disciplines to the analysis and solution of indoor air and indoor environment problems* (this is a modified definition of environmental science). Thus, at the completion of an education or training program in this area, the student (graduate) should be equipped in expertise in a specific discipline, as well as in the broad field of indoor air science. We will introduce here a concept of a three level teaching structure in application to teaching in indoor air sciences.

Level 1: Systems Approach
A very important aspect of teaching in the area of indoor air sciences is a systems approach: the indoor environment has to be seen as a system consisting of the components described above. The indoor environmental system can be different in developed and developing countries as will be elaborated further below. Any investigations or control techniques have to be approached first from a system level, before isolating a specific component of the system for more detailed, often unidisciplinary considerations. This is a principal requirement of teaching and training in this area, and as such is universal. It will be considered here to constitute the first level of the teaching structure.

Level 2: Mix of disciplines
Another universal aspect is the mix of disciplines required for a comprehensive approach to this area. Indoor air and environment experts are recruited from those whose primary education background is in science (physics, chemistry, biology, etc), engineering (mechanical, ventilation, building, etc), health (physicians, nurses, occupational practitioners, etc), management, law, etc. A complete understanding of the systems approach requires understanding of the roles and contributions of individual expertise areas to the system. This will be considered here as the second level of the teaching structure.

Level 3: Individual disciplines
The differences in the content of the material would become more pronounced at the third level of this teaching structure, which is the level of individual disciplines. But, this relates to the conclusion drawn above that while certain single discipline teaching programs are universal, some differ too significantly to be considered transferable. Since this, however, is the third level of the teaching structure in this area, most of the program could be considered transferable. There should be a differentiation here, between larger, more general programs (such as university postgraduate degrees), and often much more narrowly oriented training programs. Since the university programs would encompass all three levels of the teaching structure, they would be much more transferable, according to the conclusion above, than some of the training programs, which relate to the third level of this structure.

Organisation of teaching and training
The key issues to consider in this area are:

- who are the target audience,
- what is the purpose of learning (for example: know how to comply with the regulations, broadening of knowledge, or professional requirements),
- local requirements for teaching and training and local organisation of teaching.

The universal aspect here is, that target audience and the purpose of learning have to be the same in the places (countries, regions) where the training is to be offered compared to where it was developed, to consider the program transferable. Usually a training program is designed on the basis of knowledge in developed countries. The training program has, however, to be tailored according to the target audience and refer to the situation in the countries of the trainees. Thus, the developer of the training program has to consider the target audience of trainees, which is not necessarily the same as a target audience in his country. A training program developed in the USA or in Europe is transferable to countries of the same economic development and the target audience will usually be of the same structure in developed countries. There are, however limitations to a program being transferable even under these circumstances. For example if a particular, narrowly oriented training course is designed for example, for government managers, in a particular country, to learn how to use and apply a particular software package to estimate exposure risk for the purpose of compliance with regulations, there will be little value in offering this course in a different country. Different regulations and different procedures for compliance with regulations make training of this nature applicable only to this country. While there are many examples of unification and harmonisation in regulations and requirements resulting in unification of training programs (an example a training program for European Commercial Environment Expert), it is not feasible that in any foreseeable future world wide or even regional unification will be achieved.

The objectives of learning depend on the types of buildings that are to be considered in the training program: Office buildings (OB), residential buildings of the rich population of a country (RBR) or residential buildings of the poor (RBP). For OB in urban areas principles of teaching can be very similar, as construction techniques and architecture are identical or very similar in developed as in developing countries. More primitive OB (governmental buildings, university buildings) are encountered in developed and developing countries and may bear similarities as well although there will be exceptions due to extreme funding limitations that e.g. do not allow to make the most elementary repairs such as non tight roofs or dysfunctioning ventilation. Similar considerations apply to the RBR. In consequence, ventilation rates, building tightness, climatisation and health effects such as SBS, BRI and MCS are in the centre of study and training interest. On the other hand, RBP in developing countries (RBPdic) differ substantially from those in developed countries (RBPdec). RBPdec usually provide protection from heat, cold and ambient air pollution and are few in number as compared to the population. RBPdic usually lack climatisation, are huge in number, elicit indoor air pollution due to: (a) outdoor air pollution in a 1:1 correspondence, and (b) indoor air cooking and heating in open stoves leading to very high concentrations of carbon monoxide, sulphur dioxide, nitrogen oxides, fine particulate matter and polycyclic aromatic hydrocarbons (WHO, 1992; WHO,1997; Schwela,1996). The design of RBPdec follows at least minimal requirements from regulations with respect to ventilation and filtration, and indoor air pollution is often not directly related to outdoor air pollution. Compounds of concern in RBPdec include nitrogen dioxide from gas stoves, radon emanations from soil, organic compounds from interior design and furniture, as well as particles, gases and chemical compounds from cigarette smoking. In addition, fine particulate matter may play an important role if ambient air pollution is high and the ventilation and filtration system does not use appropriate filters. In RBPdec indoor air is much less determined by open stove cooking and heating because mostly central heating and electrical or gas boilers are in use. Biomass burning does not play a decisive role in RBPdec. An exception to this rule may be seen in the extensive use of open fires with sufficient ventilation through chimneys, which creates an outdoor air problem in some locations with an unfavourable valley topography and meteorology in RBR and RBPdec.

In developed countries the training course may address the principles of compliance testing with reference to the different regulations in different countries. With respect to different regulations, the knowledge and experience in one country would not necessarily be transferable to another one. As a rule, regulations on indoor air environments in developing countries, for example in slum areas of the megacities, in other unplanned urban areas, or in rural areas do not exist. In these cases the problem may occur that social and cultural inheritance and traditions may play a decisive role, and little or no part of the training template or advice may be transferable without looking into the social-traditional-cultural attitudes. Examples can be found in African countries. In rural and slum areas women are constructing chimneys according to traditional construction principles inherited from their ancestors. Chimneys are constructed which end one to two metres below the roofs of the huts thus discharging smoke emissions into the room. Very often no chimneys are used at all. Two issues are important with respect to training courses which address these problems: (1) lack of awareness of the building inhabitants of the risks of emissions and (2) distrust of building inhabitants with respect to non-traditional solutions. Advice from Ministries of Health or of the WHO would only help and be accepted if full awareness of the health risks associated with smoke from biofuel burning was created. This is a long way process that has to be issued in a set of training courses. Raising awareness in developing countries especially in the population of the very poor or that living in rural areas is an issue of utmost priority. Next to raising awareness is the issue of giving incentives for changing human behaviour, a task that constitutes a unique feature of training courses in indoor environment science in developing countries. It is also important to address not only governmental managers - which usually do not live in slums or rural areas but all stakeholders. In developing countries, housewives are to be included in the target audience.

Organisational aspects of teaching and training often relate to what is required after completion of the program. A degree (with, for example, a required achievement of credit points), an exam passed, a certificate of attendance, are examples of the requirements that will allow a person graduating from a program to be considered as fulfilling local specific professional criteria. While these aspects are usually of a more administrative and organisational nature, they could create real obstacles in program transfer. For example, accreditation of a course or a degree program offered by one university, to be offered at another university, is usually a task which takes many months if not years.

Economical aspects: possibilities and priorities

This aspect could be a key element, deciding not only that a training or teaching program on the quality of indoor air and environment could be conducted and how, but more fundamentally, whether this is considered an area of concern or not. In many developing countries where there is shortage of food, water, shelter, medical care, the quality of the indoor air would be at a very low level of priorities. It is obvious that it would not be a point in transferring a training course on maintenance of filtration and ventilation systems, if the indoor environment were a tent or thatched hut. An irony here is that technological solutions to significantly improve the quality of air in such environments exist and often are very simple. But on one hand there is no basic awareness that this could be a problem, and on the other hand the cost of this solutions (for example a properly vented stove), which would be insignificant in developed countries, would be totally prohibiting in developing countries.

But even in developed countries, where the cost would not be a major problem, it would not be a priority to ensure good quality of indoor environment if there are no regulations (standards or guidelines), which would make it mandatory to address the issues of the quality of the indoor environment. In both these cases, the key aspects of training would be not to focus on *what to do or how to do it,* but on *the need to do it.*

An issue to be considered in any training course is that of giving guidance for setting priorities for the items poverty, shortage of food, water, shelter, medical care, ambient air, indoor air, noise, etc. It is true that usually ambient and indoor air is of low priority in many developing countries. This attitude is; however, changing which is demonstrated by, for example, rapidly increasing interest of developing countries in the Latin American region in air quality management. Priorities usually are set by politicians on the basis of incomplete data, ignorance of the health effects of air and water pollution, and ignorance that the various issues enumerated above are closely interrelated. Poverty is a cause of water and air pollution, of lack of medical care and appropriate shelter. Very often, poverty reduction and economic development is a first priority. Water and air pollution, however, will in turn impede economic development though increased health costs and loss of human resources. All the issues named above are part of the environmental system, and, consequently, the principles of systems approach are to be applied as well. Therefore, indoor air science cannot be trained without taking into consideration this wider system. The benefits of clean air and water to economic development have to be elucidated in a training course. An example in the case of ambient air are the training courses of the Swedish Meteorological and Hydrological Institute (SMHI, 1998), in which all these issues are addressed. This consideration leads to the need to do something in indoor air mentioned in the next section.

Solutions for exchange of education and training programs

Rising awareness

In general terms training programs can be classified as "what to do", "how to do it" and "need to do it" types. Where "what to do" indicates programs focused on what building design, maintenance, operational aspects or what air quality parameters to target; "how to do it", implies focus on technical, instrumental or design options that are available for application, and "need to do it" means provision of rationale for controlling air quality. Most of the *how to do it* type education and training programs could be considered transferable between countries and regions, unless the focus of a program is so narrowly linked to some specific aspects of the local regulations or approaches that it is not applicable outside the country or jurisdiction boundaries. Not all "how to do it" knowledge is transferable, because some solutions may not fit into the cultural and traditional background or may be too expensive. *The need to do it type* programs would not be considered as transferable, but as developed by the program designer for a specific area or country.

The most important aspect of *what to do* or *how to do it* programs is the system approach to learning, and the more general the program is, the easier it is to implement this approach. Thus in general, transfer of university programs would present mainly organisational and administrative problems, while transfer of more narrowly oriented courses would present more problems, ranging from the need for content modification to considering the program non-transferable.

The "what to do" is in the decision of the politician of a country as is the "need to do it". An international organisation such as WHO, for example, can, however, give in its training courses guidance on the need, on the what, and on the how. With respect to the need, WHO cannot tell countries that there is a need but WHO can make politicians aware of a potential need by pointing out the health effects caused by "no action" and their economic consequences. At least an incentive can be given to governmental managers to consider the need for action. The guidance on the "how" and the "what" will be accepted and applied only if the "need" is agreed upon.

Teaching considerations

A very important aspect of general type programs, teaching a systems approach to indoor air, is to ensure that students obtain a very strong background in one specific area of knowledge or expertise, and a broad, umbrella type knowledge in relation to the whole area. This approach is not unique to teaching in indoor air science and practice, but to any interdisciplinary teaching. An example of this is the environmental science major, undergraduate program developed and offered by the Queensland University of Technology, Brisbane, Australia. To summarise the program, undergraduate students undertaking the environmental science major, are strongly recommended to undertake this either as a double major or major and minor in any of the following areas: mathematics, physics, chemistry, earth sciences or life sciences. The environmental science major program has four units which are the same for all environmental science students, while four other units are closely related to and strengthen the areas which are of direct significance for environmental applications (for example an extended program in fluid mechanics and transport theory for environmental science major/physics major students) (Morawska, 1998). Another important aspect of interdisciplinary programs is that the systems approach students learn is broad enough, that it could be applied to systems and situations, other than those, which were the main focal areas for the students. As an example, a training course could focus on the IAQ risks within a countries' building stock excluding the possible occupational risks. The types of buildings to be considered include OB, RBR, and RBP. The fundamental IAQ questions to be addressed would include general information on indoor air pollution and its potential impacts on health. Combustion products generated indoors including tobacco smoke and emissions from building materials, equipment and furnishings; outdoor air pollutants; moisture and biological agents; principles of ventilation requirements and thermal comfort; capacities, designs and maintenance of ventilation systems; balancing of the IAQ air exchange and energy conservation; indoor air and building related health problems. Additional issues that could be addressed: Setting of IAQ standards and approaches to achieving those standards, including applicable rules and regulations; general approaches to IAQ monitoring techniques including the use of practical field test equipment; symptom evaluation techniques for building occupants; and options for IAQ management including building codes; and equipment permits, material labelling, user instruction and training, IAQ guidelines and standards.

Important global aspects of education and training in the area of indoor air sciences, discussed extensively above, are clearly defined objectives and target audiences, for the program. Programs, which clearly identify both aspects, are much easier to transfer, if the clearly defined requirements on the receiving end are similar.

How to address the differences, of more narrowly oriented programs, such as training courses? The best recipe for courses like this is:

- the systems approach component and global aspects of the program can be taught by the program designer or provider,

- area or country specific aspects should be taught by a local expert or in collaboration with a local expert.

Examples of these approaches are Indoor Air Quality Assessment courses, in Sydney, Australia of which about two-thirds were taught by a Canadian expert and one third by Australian experts. The component presented by the Australian experts consisted mainly of case studies related to the Australian climatic conditions and regulation compliance requirements. Another example is a training course: Indoor Air in Hospital Environment, presented by one of the authors of this paper (LM) to a large audience of engineering and medical practitioners from health care facilities in Taipei, Taiwan. About three quarters of the course was the author's presentation on various general and hospital specific aspects of indoor air, with a focus on particle pollution. The remaining quarter was presented by Taiwanese researchers and practitioners, and consisted of a report from a project conducted in several hospitals in Taiwan on air quality in hospital isolation rooms. Another example is a broader training course offered by several experts from different countries and continents, representing the International Society of Indoor Air Quality and Climate (ISIAQ). The course has already been presented in Sweden and the USA (and included Sweden and USA focused presentations), and attended by those whose professional duties require a broad knowledge of global trends and approaches to indoor air quality and environment. In all three cases the courses received top assessments by the participants.

In conclusion, transfer of knowledge and technology in teaching in the area of indoor air sciences is possible and desirable. The success of program transfer depends on the understanding of the philosophy of teaching in this area as well as on understanding local needs, requirements and limitations. The globalisation of education and training require continuous upgrades of the teaching programs to follow technology developments, as well as the ever changing social and economical conditions and requirements of countries and regions.

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